Remarks

Claims 1-26 were pending. Claims 1, 3, and 14-21 have been amended, and claims 22-26 have been canceled. As a result of this amendment, claims 1-21 remain pending. Reexamination and reconsideration are requested in light of the accompanying amendments and remarks.

Applicants confirm the election of Group I, claims 1-21. Claims 22-26 have been canceled without prejudice pending their resubmission in a timely filed divisional.

The rejection of claims 1-21 under 35 U.S.C. § 112, second paragraph as being indefinite has been overcome. Claim 1 has been amended to remove the term "fluorine-free" from the preamble and the subsequent references to the "fluorine-free plasma cured material." Claim 3 has been amended to depend from claim 1, and the antecedent basis for the dielectric material has been corrected from "organic" to "porous." Claims 14-21 have also been amended to remove the term "fluorine-free plasma cured material." These amendments have been made for purposes of clarification and for no other purpose. Therefore, claims 1-21 are in compliance with 35 U.S.C. § 112, second paragraph.

The rejection of claims 1-21 under 35 U.S.C. § 112, first paragraph as being non-enabling has been overcome. Claim 1 has been amended to recite a "Si-containing porous dielectric material." Therefore, claims 1-21 are fully enabled. Claim 21 has been amended to make it clear that the comparison is to similar Si-containing porous dielectric material cured in a furnace. Therefore, claims 1-21 are in compliance with 35 U.S.C. § 112, second paragraph.

The rejection of claims 1-21 under the judicially created doctrine of obvious-type double patenting as unpatentable over claims 1-33, 50-52, and 55-66 of U.S. Application No. 10/623,729 (now US 6,756,085) in view of Shi (6,284,056) is respectfully traversed. (This patent number is believed to be 6,284,050.) According to the examiner, "[t]he 10/623,729 application differs from the present application by first employing UV curing, then plasma treating (claim 28-33), where the plasma gas may the claimed combination of N_2 + CH_4. Also, the material being cured by the (729) application need not be porous, although porous is not excluded, but the present application starts the claimed process with a material or film that has already been sufficiently processed or treated to be a porous dielectric material, then "plasma cures" with plasma gases as claimed by (729). In both cases, the material being treated may be HSQ or MSQ; or a combination thereof when specific compounds are given. It would have been obvious

to one of ordinary skill in the art that the creation of the initial porous dielectric material of the present case has some initial curing steps, and it would have been expected for one of ordinary skill in the art to use processes known in the art to achieve the initial state."

A double patenting rejection of the obvious-type is "analogous to the nonobviousness requirement of 35 U.S.C. §103", except that the patent principally underlying the double patenting rejection is not considered prior art. MPEP 804 (citing *In re Braithwaite*, 379 F.2d 594, 154 USPQ 29 (CCPA 1967)). Therefore, any analysis employed in an obvious-type double patenting rejection parallels the guidelines for analysis of a 35 U.S.C. §103 obviousness determination, and the factual inquiries set forth in *Graham v. John Deere Co.* are employed when making an obvious-type double patenting analysis. MPEP 804 (citing *In re Braat*, 937 F.2d 589, 19 USPQ2d 1289 (Fed. Cir. 1991); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985)). One of these factual inquiries is ascertaining the differences between the prior art (cited U.S. patent applications) and the claims at issue. Moreover, to establish a *prima facie* case of obviousness, there must be some suggestion or motivation to modify the references or to combine the reference teachings, and the reference or combined references must teach or suggest all the claim limitations. For the following reasons, applicants submit that the Examiner has not presented a *prima facie* case of obviousness.

The present invention involves a "process for making a plasma-cured material comprising: providing a porous dielectric material . . . and plasma curing the porous dielectric material with a fluorine-free plasma gas . . . ." Contrary to the examiner's position, the formation of the initial porous dielectric material does not have some initial curing steps. Porous dielectric materials typically require *a curing process after deposition*, as discussed in paragraphs 0012-0014. Various curing methods have been used including thermal curing, UV curing, and plasma curing. UV curing and plasma curing eliminate the need to thermally cure the porous dielectric material.

The present invention is directed to plasma curing the porous dielectric material with a fluorine-free plasma gas. In contrast, the '729 application is directed to UV curing the dielectric material. UV curing yields a material with improved modulus and material hardness. The improvement is typically greater than or about 50%. The UV cured dielectric material can optionally be post-UV treated. The post-UV treatment reduces the dielectric constant of the

material while maintaining an improved elastic modulus and material hardness as compared to the UV cured dielectric material. UV cured dielectrics can additionally exhibit a lower total thermal budget for curing than for furnace curing processes. See Abstract, col. 7, lines 36-41, col. 8, lines 14-67 of US 6,756,085. In contrast, in the present invention, the porous dielectric material is plasma cured with a fluorine-free plasma gas.

Shi describes an ultraviolet-assisted chemical vapor deposition system. The processes include one or more depositions, one or more UV exposures, and one or more anneals. According to the examiner, "[g]iven teachings of Shi et al that treat like materials, and the present claims, where the "plasma curing" is after porous film or material formation, it would have been obvious to use UV treatment techniques as taught by Shi et al, followed by the present cases' "plasma curing", especially as Shi et al recommends post-treatments involving heat after UV curing." However, as discussed above, the *formation of the porous dielectric material does not require curing*. After the porous dielectric material is formed, it can be cured if desired using various processes. The present invention is directed to "providing a porous dielectric material . . . and plasma curing the porous dielectric material with a fluorine-free plasma gas . . . ." Shi neither teaches nor suggests this process, either alone or in combination with the '729 application.

The examiner also stated that "the present case is more generic than (729) in not claiming the multi-stage treatments as does the (729) case, and that the instant claims may be considered a substep of or [sic] the plasma species of (729)'s "post-UV treating" when considered in view of Shi et al, as discussed above." However, in contrast to the examiner's position, the present application is not a substep of the '729 application. Both applications cure dielectric materials, but they do so using different processes. The '729 application UV cures the material, while the present application plasma cures with a fluorine-free plasma gas.

The rejection of claims 1-21 under 35 U.S.C. §103(a) as unpatentable over Catabay (U.S. 6,346,490), in view of Usami (U.S. 6,133,132) or Chung (U.S. 6,231,989) or Liu (U.S. 6,647,994) is respectfully traversed. Catabay teaches treating the damaged surfaces of a low k carbon-containing silicon oxide material with one or more carbon-containing gases in the absence of an oxidizing agent. The treatment is designed to inhibit subsequent formation of silicon-hydroxyl bonds when the damaged surfaces of the low k dielectric material are thereafter

exposed to moisture. The treatment is carried out after oxidizing or ashing the resist mask to remove the mask. The treatment can optionally be performed after the initial step of etching the low k carbon-containing silicon oxide dielectric material to form vias or openings.

The examiner correctly noted that there is no explicit statement in Catabay as to whether the low k dielectric is porous. However, the examiner stated that Catabay's "plasma treatment may be combined with N_2 densification, which would have been expected to be harder than the initial dielectric, and which implies that the initial untreated dielectric is relatively porous in order for densification to be induced, although no explicit teaching concerning porosity or lack thereof is found in Catabay et al." Contrary to the examiner's position, the N_2 densification process does not suggest a porous material. The N_2 densification process, cited at col. 5, line 59 to col. 6, line 14, is described in U.S. Patent No. 6,114,259. It involves forming a densified layer on and adjacent the exposed surfaces of a low k carbon doped silicon oxide dielectric material. The densified layer comprises silicon and nitrogen. The layer has a sufficient thickness to prevent degradation of the low k carbon doped silicon oxide dielectric material during the oxidizing step to remove the photoresist layer. An opening is etched in the low k carbon doped silicon oxide dielectric material, photoresist layer, and protective capping layer. The sidewalls of the opening are treated with a plasma to form the densified layer before the step of oxidizing or ashing the photoresist. U.S. Patent No. 6,114,259, Col. 3, line 64 to col. 4, line 39, and col. 4, line 63 to col. 5, lines 21.

Furthermore, the process cited in Catabay (col. 1, lines 50-60) for making low k carbon containing silicon oxide dielectric materials does not involve a porous material. U.S. Patent No. 6,303,047 describes a low dielectric constant multiple carbon-containing silicon oxide dielectric material. The material can be formed by reacting a mild oxidizing agent with a multiple carbon-substituted silane having only primary hydrogens bonded to the carbon atoms having a specified formula. In order to form a porous material, particular steps must be performed to create pores or voids, and the '047 patent does not teach any such steps. Neither the '047 patent nor Catabay ever mentions a porous dielectric material.

Therefore, Catabay does not teach or suggest the use of a porous dielectric material.

In addition, Catabay does not teach or suggest plasma curing a porous dielectric material, as claimed. Catabay states that the treatment can be carried out either with or without the use of

plasma. First, if there is no plasma, there can be no plasma curing. Second, even when plasma is used in Catabay's treatment of damaged surfaces of low k carbon-containing silicon oxide dielectric materials, the process is not plasma curing, as claimed. In the present invention, plasma curing the porous dielectric material provides, among other things, chemical stability. The porous dielectric materials of the present invention are resistant to chemicals, such as cleaning solutions and chemical polishing solutions, as well as plasma damage during photoresist ashing and dry etching processes. See para. [0060].

Catabay's treatment takes place after the step of oxidizing or ashing the resist mask to remove the mask. It can also be carried out after the initial step of etching to form vias. Thus, Catabay's process is designed to treat damage that the present invention prevents from occurring in the first place. Catabay's material cannot be cured, even after the first treatment, because the damage occurs in both the etching and oxidizing steps.

According to the examiner, "[n]o comparison of before and after plasma treatment values, relative or specific, for the claimed dielectric constant, elastic modulus, or hardness is given, however the relationship as claimed is implied as noted above." However, as discussed above, Catabay does not teach or suggest using a porous dielectric material, nor does it teach or suggest plasma curing the porous dielectric material. Therefore, the claimed properties would not have been expected.

Usami, Chung, and Liu do not cure the deficiencies of Catabay. Usami teaches a thermally cured material. Col. 3, lines 7-21, and col. 4, lines 30-46. Chung also teaches thermally curing the material. Col. 7, line 45 to col. 8, line 17. Thermal curing is a different curing process from the claimed plasma curing. A proper combination of either Usami or Chung with Catabay, would result in the use of a thermally curing porous dielectric material which was then surface treated according to Catabay. This is not the claimed invention.

Liu does not discuss whether its material is cured or not. As Catabay does not teach or suggest plasma curing the porous dielectric material, the combination does not teach or suggest the claimed invention.

The examiner has not presented a prima facie case of obviousness, particularly in view of the examiner's admission that the Catabay does not show a comparison of the dielectric constant, eleastic modulus, or hardness before and after its plasma treatment.

Therefore, claims 1-21 would not have been obvious to one of ordinary skill in the art at the time the invention was made over Catabay in view of Usami, Chung, or Liu.

Conclusion

Applicants respectfully submit that, in view of the above amendments and remarks, the application is in condition for allowance. The Examiner is encouraged to contact the undersigned to resolve efficiently any formal matters or to discuss any aspects of the application or of this response. Otherwise, early notification of allowable subject matter is respectfully solicited.

Respectfully submitted,
DINSMORE & SHOHL LLP

By Patricia L. Prior
Patricia L. Prior
Registration No. 33,758

One Dayton Centre
One South Main Street, Suite 1300
Dayton, Ohio 45402-2023
Telephone: (937) 223-2050
Facsimile: (937) 223-0724